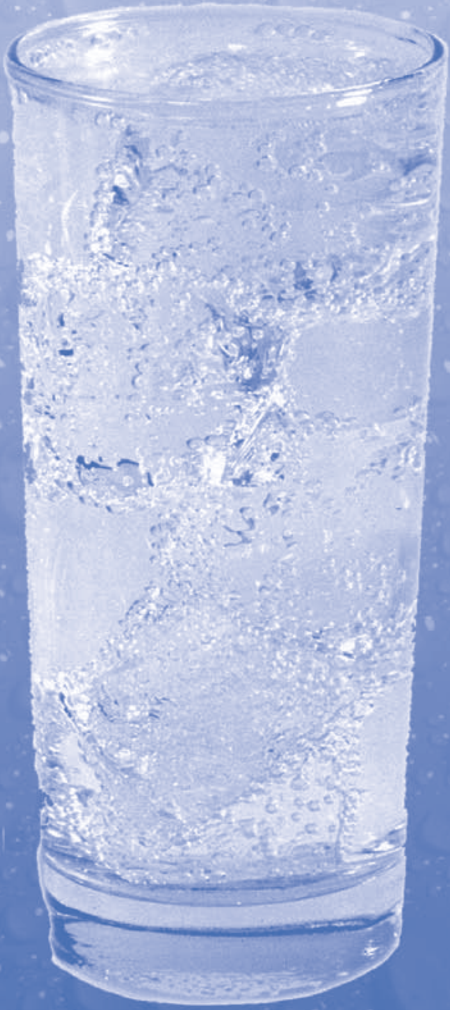
Drinking Water

Common Water Quality Problems and Their Treatment



South Carolina Department of Health
and Environmental Control

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Introduction

The first step in solving any water quality problem is to have a proper analysis performed on the water. The Department of Health and Environmental Control provides this service as technical assistance to the owners of private wells in South Carolina.

For a routine chemical analysis of the water, a one-half gallon sample of the water is required. The sample must be collected in a clean, spillproof plastic container. This group of analyses includes: pH, alkalinity, chlorides, hardness, nitrates, calcium, magnesium, copper, iron, manganese, and zinc. Fluoride may also be tested as requested.

Other analyses are available upon request and at the discretion of the EQC (Environmental Quality Control) Regional office in your area. Because many kinds of analyses require special containers, preservatives, or sample collection techniques, we recommend contacting one of the DHEC Regional EQC offices prior to submitting any special requests for analyses. A list of these offices may be found in the back of this booklet.

Water samples may be submitted at most of the 46 county health departments, or at the Regional EQC Office in your area. Courier service to the DHEC laboratory is restricted in some areas. Always call ahead to determine the best time to bring in your water sample.

Collecting a Water Sample For
Metals and Minerals Analysis

1. Open a cold water faucet and allow it to run for three to five minutes. This flushes any standing water from the water pipes.

2. Rinse the container well several times with the water you are sampling. Fill the container and securely tighten the cap.

3. Write your name, address, and the date and time the sample was collected on a piece of paper and tape it to the sample container.

You will also be asked to complete a request form for the sample when you bring it in.

4. Take the sample to your local county health department or regional environmental quality control office. Samples may also be submitted at DHEC's central office at 2600 Bull Street in Columbia.

Water samples for metals and minerals analyses must be received in the DHEC laboratory within three days of collection.

You will receive your sample results by mail in about two to three months.

Interpreting the Metals and Minerals Analysis of Your Drinking Water

Each of the tests routinely performed on a water sample are briefly described below. For problem areas, see the detailed descriptions that follow.

Alkalinity
This is a measure of the water's ability to neutralize acids and bases; a process known as buffering. As alkalinity increases, the water becomes more stable and less likely to corrode household plumbing. An alkalinity of more than 30 mg/l is desirable in drinking water.

Calcium
See Hardness.

Chlorides
Chlorides are usually related to the "salt" content of the water. Water with a high chloride concentration may have a salty taste and will increase the corrosion of plumbing and home appliances. The maximum concentration of 250 mg/l chlorides is recommended.

Copper
Copper is a metal most commonly dissolved into drinking water by the corrosion of copper plumbing. It can cause a bitter taste in the water and produce green stains on plumbing fixtures. The maximum recommended limit for copper is 1.3 mg/l.

Hardness
Hardness is a result of the amount of dissolved calcium and magnesium in the water. Hard water does not lather soap well and can form a hard scale when heated. Some hardness in water is desirable to reduce corrosion. Water having a hardness between 50 and 150 mg/l will not interfere with most household uses of the water.

Iron and Manganese
Both of these are naturally occurring metals that react very similarly in drinking water. They can give water a metallic taste and will produce rusty or grayish stains on fixtures and in laundry. The recommended limit for these metals is 0.3 mg/l iron; 0.05 mg/l manganese; or a total of no more than 0.3 mg/l for both.

Magnesium
See Hardness.

pH
pH is an artificial scale used to measure acidity. A pH of 7 is neutral, neither acidic nor basic. As the scale decreases from 7 to 0, the water becomes more acidic. As the pH increases from 7 to 14, the water becomes more basic. Most well water has a pH between 5 and 9. The recommended range for drinking water is from 6.5 to 8.5.

Total Dissolved Solids
The total dissolved solids test is a measure of the amount of dissolved and suspended material in the water. "Mineral water" typically has a high total dissolved solids level. The maximum recommended level for total dissolved solids is 500 milligrams per liter (mg/1).

Zinc
Zinc in drinking water is usually caused by the corrosion of galvanized plumbing materials. Above the recommended limit of 5.0 mg/I, zinc can cause a metallic taste and a milky appearance in water.

Commonly Used Abbreviations in Water Analyses

mg/l
Milligrams per liter. In water, this is the same as one part per million, or about one drop of water in 55 gallons of water.

ug/l
Micrograms per liter. One part per billion. One milligram per liter is equal to 1000 ug/l.

<
Less than. On a test result, this generally means that the concentration of the item tested was below the minimum concentration that our instruments could detect.

>
Greater than or more than.

Chlorides

Chlorides, not to be confused with chlorine, are in nearly all water supplies. They are usually associated with the salt content and the amount of dissolved minerals in water. The recommended limit for chlorides is 250 milligrams per liter (mg/1). This is the concentration in water where most people will notice a salty taste.

CAUSES:

Chlorides are soluble mineral compounds that are dissolved by the water as it filters through the earth. The amount of chlorides in water are determined by the type of rocks and soils it has contacted. In coastal areas, the leaking of sea water into a well can also be a cause of increased chlorides.

Water supplies having high concentrations of total dissolved solids (TDS) may also contain elevated chloride levels as part of the TDS. As much as 50 percent of the TDS may be due to chlorides.

Human and animal wastes contain a high concentration of chlorides. If a sudden, large increase in the chloride content is noticed, or if the well water begins to taste salty, then samples should be taken to see if the well has been contaminated.

EFFECTS:

The presence of chlorides in drinking water is generally not considered to be harmful to humans or animals. The most noticeable effect of high chlorides is a salty taste. If a water softener is being used, the taste will be even more pronounced.

In mineralized waters (high TDS), chlorides contribute to the corrosion of household appliances and domestic plumbing by preventing the formation of protective oxide films on exposed surfaces. The average life of water heaters has been estimated to shorten by one year for every 100 mg/l chloride over the first 100 mg/I.

TREATMENT:

Chlorides cannot be easily removed from drinking water. Of the available treatment processes, reverse osmosis (RO) and deionization (DI) are capable of effectively treating the entire household supply. However, both are relatively expensive. Because deionized water can also be corrosive, DI units are not recommended for whole-house use.

If the taste of the water is the only concern, the treatment methods described below are available as point of-use devices. A point-of-use device is a small treatment unit that will produce between 10 and 15 gallons of water per day for drinking and cooking. The device is usually located near the kitchen sink.

1. **Reverse osmosis (RO):** RO units remove dissolved minerals by forcing the water, under pressure, through a synthetic membrane. The membrane contains microscopic pores that will allow only molecules of a certain size to pass through. Since the molecules of dissolved mineral salts are large compared to the water molecules, the water will squeeze through the membrane leaving the mineral salts behind.

   A properly operated RO unit is capable of removing 90 percent of the dissolved mineral salts from a water supply. A pre-filter is usually required to protect the membrane from abrasion. The membrane cartridges require periodic replacement.

2. **Distillation:** Distillation units are better known as "stills." They are manufactured from heat-resistant glass or stainless steel. Stills work by heating small amounts (less than 2 gallons) of water to produce steam. The steam is then collected and condensed back into water. The dissolved minerals will not vaporize and are left behind in the heating chamber.

   Stills require frequent, rigorous cleaning to remove the baked-on mineral salts. The "flat" taste from boiling the water can be reduced by pouring the water back and forth between two containers to aerate it.

3. **Deionization** (DI): Deionization units are available as small, wall-mounted cartridges containing ion exchange resins. When water passes through the cartridge the dissolved mineral salts are retained in the resin, producing a mineral-free water.

   The DI cartridges have a limited life. They will usually show a color change in the resin to indicate when they should be replaced.

4. **Combination Point-of-Use Devices:** These are multistep treatment systems designed to fit under the kitchen sink. They use a pre-filter, RO membrane **or** DI cartridge, and a carbon polishing filter top and produce up to 15 gallons of water per day. The treated water is stored in a small pressure tank and piped to a special faucet on the sink. Each of the treatment steps is in a cartridge form.

Copper

Copper is both an essential and beneficial element for plant and animal life. It rarely occurs naturally in a water supply, and its presence is generally not considered to be a health hazard. High copper concentrations give the water a bitter taste, which discourages people from drinking potentially harmful amounts. The recommended limit for copper in drinking water is 1.3 milligrams per liter (mg/1).

CAUSES:

Copper is usually present in drinking water as a result of the corrosion of copper plumbing. The more commonly occurring causes of corrosion are listed below:

Acidic Water: A soft, acidic water will dissolve small amounts of copper from the plumbing. The amount of copper in the water will increase with the length of time the water has been standing in the pipes.

Dissolved Solids: High concentrations of dissolved solids and chlorides increase the ability of the water to conduct an electrical current. The increase in conductivity accelerates corrosion by making it easier for the chemical reactions involved in corrosion to occur.

Galvanic Corrosion: Galvanic corrosion occurs when two different metals come in contact with each other. The differences between the two metals produce an electrical current, causing one of the metals to corrode. An example of this would be connecting a brass fitting to a galvanized pipe.

EFFECTS:

The most noticeable effect produced by copper is a blue-green stain on plumbing fixtures. The water itself may also have a blue color. Copper above 1.3 mg/l will give the water a very bitter, medicinal taste. To avoid drinking possibly harmful levels of copper or other dissolved metals, the faucet should be run for several minutes any time an “off” taste is noticed. This will flush any metal-containing water from the pipes.

Copper can cause a green “curd” to form when soap is added to the water. People with light colored hair or people using a hair coloring may notice a greenish color to their hair when washing it in water with an elevated copper concentration. Copper is also toxic to aquarium fish.

In some people, drinking water containing an extremely high amount of copper can cause temporary stomach cramps and general intestinal discomfort. This usually occurs only when copper concentrations are above 60 mg/l.

TREATMENT:

1. Acidic Water: Copper present as the result of acidic water may be eliminated by neutralizing the acidity of the water. This may be done by using a metering pump to add small amounts of an alkaline solution (such as soda ash and water) to the water, or by using a neutralizing filter. For further information, please refer to the Bulletin entitled "Corrosive (Acidic) Water."

2. Dissolved Solids: Corrosion due to a high concentration of dissolved solids may be treated by using a reverse osmosis filter to drastically reduce the solids content. However, this method of treatment is very expensive.

   An alternative treatment would be to use a polyphosphate compound. The polyphosphates will not reduce the dissolved solids content of the water, but will help to protect the plumbing from corrosion by forming a protective coating on the exposed metal surfaces.

3. Galvanic Corrosion: Galvanic corrosion can be eliminated by placing a dielectric (plastic or rubber) joint between the two different metals to break the electrical current.

Corrosive (Acidic) Water

The corrosiveness of water is largely due to three factors; the pH, the amount of alkalinity, and the hardness of the water.

Water in nature will be either acidic, neutral, or basic. pH is a measure of how acidic or basic the water is. It is expressed as a number from 0 to 14. Neutral water, which is neither acidic or basic, has a pH of 7. As pH values decrease from 7 to 0, the acidity of the water increases; pH values from 7 to 14 show increasing basicity. Well water usually has a pH between 5 and 9.

Alkalinity is a measure of the water's ability to neutralize acids and bases. It is mostly due to the amount of naturally occurring carbonate and bicarbonate compounds which have been dissolved by the water. Because the alkalinity can neutralize both acids and bases, it allows the water to maintain a stable pH. This process is known as buffering. Hardness is due to the amount of calcium and magnesium dissolved in the water. "Hard" waters are less corrosive than "soft" waters. Hardness helps to prevent corrosion by adding to the buffering ability of the water and by forming a protective film on the pipe walls.

For most domestic water, corrosion will be minimal when the pH is near neutral (7), the alkalinity is greater than 30 milligrams per liter (mg/1), and the hardness is more than 50 mg/l.

CAUSE:

The pH, alkalinity and hardness of a water are a result of the amounts and types of minerals dissolved into the water from the surrounding soils and rocks. Water's natural acidity is caused by the presence of carbonic acid and carbon dioxide. When the amount of alkalinity and hardness are low, the water cannot be neutralized and the soft water may attack any exposed metal surfaces.

EFFECTS:

Corrosive water will attack any exposed metal surface, slowly dissolving the metal into the water. Constant exposure to corrosive water will noticeably shorten the life of household plumbing, eventually causing pin-holes to appear in the pipes. Corrosion will occur at any place in the water system where water contacts metal. This includes pipes, faucets, well casings, pressure tanks, and the well pump itself.

With copper plumbing, corrosion will cause blue-green stains in sinks and tubs, and will give the water a bitter, medicinal taste. The taste will be most noticeable when the water has been standing in the pipes for long periods of time, such as overnight. Anytime a taste is noticed, or when the water has been in contact with the plumbing for longer than six hours, the water should be allowed to run for several minutes before using. This flushes any metal-containing water from the pipes.

The corrosion of steel or galvanized metal will cause a rusty stain in fixtures, give the water a metallic taste, and may produce cloudy water on occasion.
In addition to damaging the water system, corrosive water can also interfere with other water treatment. Iron and manganese cannot be easily removed from acidic water. In this case, the acidity must be neutralized prior to the iron removal treatment.

TREATMENTS:

1. pH Adjustment: This method uses a small metering pump and mixing tank. The metering pump adds small amounts of a mixture of soda ash and water to the well water whenever the well pump is running. The soda ash (sodium carbonate) raises the pH and the alkalinity of the well water, chemically neutralizing the acidity.

   The use of soda ash will not increase the hardness of the water. However, this method can be used with almost any pH level.

2. Neutralizing Filters: These are essentially a pressurized tank containing a filter bed of calcium carbonate or calcite. As the acidic water passes through the filter, the carbonic acid and carbon dioxide combine with the calcium carbonate neutralizing the acidity. Because the filter bed is composed of a calcium compound, neutralizing filters will increase the hardness of the water, as well as increase the pH and alkalinity. Neutralizing filters work best at a pH between 6 and 7.

   If the pH is between 5 and 6, a magnesium oxide must be added to the filter bed to adequately neutralize the acidity. They should not be used with a pH below 5. Neutralizing filters must be backwashed periodically to remove sediments trapped within the filter bed. Most manufacturers offer both a manually operated and an automatic backwash cycle.

3. Polyphosphates (Micromet, Shan-No-Coor, etc.): These compounds deposit a protective layer on exposed metal surfaces. They do not change the acidity of the water. Polyphosphates work best within a pH range of 6.8 to 7.4. It may take as long as eight weeks for the protective coating to form.

Fluoride

Fluorine is the 13th most common element in the earth's crust. In the form of fluoride, it is found in varying amounts in all natural waters. High fluoride concentrations are not usually found in surface waters, such as lakes and streams. However, they can occur in groundwater supplies. In many communities, fluoride is added to water to help prevent dental cavities.

The U. S. Environmental Protection Agency has established a twofold limit for fluoride in drinking water: A limit of 2.0 milligrams per liter to avoid the dental fluorosis associated with long term exposure to excessive fluoride; and a maximum allowable level of 4.0 mg/l. While the EPA does regulate the amount of fluoride in drinking water, it also strongly supports water fluoridation at optimum levels to aid in preventing dental cavities.

CAUSE:

Fluoride is dissolved into water from fluoride bearing minerals that occur naturally in the earth. In the United States, these minerals occur only in a few regions of the country. In South Carolina, fluoride is more common toward the coastal region.

EFFECTS:

Fluoride is a normal part of the human diet. At an optimum concentration of 1.0 mg/l in drinking water, fluoride produces no ill effects. Children who have received optimally fluoridated water from birth have shown as much as a 65 percent reduction in the occurrence of cavities when compared to areas with little or no fluoride. The beneficial effect of fluoride diminishes greatly as the fluoride concentrations decrease below 0.7 mg/l.

Children exposed to excessive amounts of fluoride while their teeth are developing can develop dental fluorosis. Dental fluorosis appears as whitish or brown spots on the teeth. The occurrence of dental fluorosis increases as the fluoride concentration increases. At fluoride levels below 2.0 mg/l, dental fluorosis is rare. At 3.0 mg/l, brown stains can be found in a small percentage of the population. In the United States, dental fluorosis is the only adverse health effect observed from long term exposure to excessive fluoride in drinking water.

TREATMENT:

Excessive fluoride is a concern only in the small amount of water used for cooking and drinking. Other household uses of the water are not affected by excessive amounts of fluoride. Removal of fluoride from the entire household water supply is expensive and generally unnecessary. For the small amount of water used in cooking and drinking, point-of-use treatment devices are a more reasonable solution.

Point-of-use devices are small treatment units that produce up to 15 gallons of water per day for drinking and cooking. The device is usually located near the kitchen sink. All of the methods described below are available as point-of-use devices.

1. **Reverse Osmosis (RO):** RO units remove dissolved minerals by forcing the water, under pressure, through a synthetic membrane. The membrane contains microscopic pores that will allow only molecules of a certain size to pass through. Since the molecules of dissolved minerals are large in comparison to water molecules, the water will squeeze through the membrane leaving the minerals behind. A properly operated RO unit is capable of removing about 90 percent of the dissolved minerals from a water supply.

2. **Distillation:** Distillation units are better known as "stills." They are made of either heat-resistant glass or stainless steel. Stills work by heating small amounts (less than 2 gallons) of water to produce steam. The steam is then collected and condensed back into water. The dissolved minerals will not vaporize and are left behind in the heating chamber.

   Stills require frequent, rigorous cleaning to remove the baked-on mineral salts. The "flat" taste from boiling the water can be reduced by pouring the water back and forth between two containers to aerate it.

3. **Deionization (DI):** Deionization units are available as small, wall-mounted cartridges containing ion exchange resins. When water passes through the cartridge, the dissolved minerals are retained in the resin, producing a mineral-free water. The DI cartridges usually show a color change in the resin to indicate when they should be replaced.

4. **Combination point-of-Use Devices**: These are multi-step systems which use a pre-filter, RO membrane or DI cartridge, and a carbon polishing filter. They treat up to 15 gallons of water per day. The treated water is stored in a small pressure tank and piped to a special faucet on the kitchen sink.

Where treatment is not desirable or practical, bottled water may be used as an alternative source of drinking water. A chemical analysis of the water (including fluoride) will sometimes be listed on the label.

Hardness

Hard water is one of the most common water quality problems in the United States. In the past, hardness was measured by the amount of soap that had to be added to water to produce a lather. It is now measured as the concentration of dissolved calcium and magnesium compounds (expressed as calcium carbonate).

There is no firm dividing line between hard and soft water. However, for most household uses, a hardness of between 50 and 150 milligrams per liter (mg/1) is acceptable. Hardness may sometimes be expressed as grains per gallon (gpg) instead of mg/l. 1 gpg is equal to 17.1 mg/l.

CAUSE:

The amount of naturally occurring calcium and magnesium compounds dissolved by the water as it filters through the earth will determine its hardness. Hardness varies with location and the types of minerals and rocks in the earth.

EFFECTS:

Despite all of the problems it causes, hard water is not considered to be a health hazard. Moderate amounts of hardness are desirable because of the protective coating it produces on exposed metal surfaces. Excessively hard water, however, will cause a hard, chalky scale (boiler scale) to form when the water is heated. Water heaters are especially affected by hardness. The boiler scale will accumulate on the heating elements, reducing their heating capacity, and eventually causing them to burn-out.

Hard water will form a white, powdery residue on plumbing fixtures, and will cause spots on dishes. Because calcium and magnesium compounds are not very soluble in cold water, ice made from hard water may contain white particles. Vegetables cooked in hard water may be tough. More soap must be added to a hard water to produce a lather. With very hard water, soap will form a sticky "curd," which is difficult to remove from fabrics and containers. Laundry washed in hard water will be stiff and dingy. Hair becomes dull and limp when washed in hard water.

TREATMENT:

The minerals that cause water hardness can be removed by a water softener. Water softeners use an ion exchange process to replace the calcium and magnesium that cause hardness with an equivalent amount of sodium, which does not contribute to water hardness.

With use, all of the sodium in a softener will eventually be replaced by calcium and magnesium. When this occurs, the softener must be regenerated to maintain its softening ability.

In regeneration, the softener is filled with a concentrated salt solution. The sodium in the salt solution replaces the calcium and magnesium in the softener, restoring it to its original condition. Most manufacturers offer either a manual or an automatic regeneration cycle in their softeners.

Ion exchange softeners produce a water with near zero hardness. Because a moderate amount of hardness is desirable, some individuals choose to soften a portion of the water and blend it with unsoftened water to produce a final hardness of 50 to 100 mg/1.

NOTE: WATER SOFTENING INCREASES THE SODIUM CONTENT OF THE WATER BY AN AMOUNT EQUAL TO ONE-HALF OF THE HARDNESS REMOVED. PEOPLE WHO MUST RESTRICT THEIR SODIUM INTAKE FOR MEDICAL REASONS SHOULD CONSIDER THIS ADDED SODIUM IN THEIR DIET. ADVISE YOUR DOCTOR OF THE CHANGE IN THE SODIUM CONTENT OF YOUR WATER BEFORE DRINKING OR COOKING WITH THE WATER.

In cases where the water hardness exceeds 200 mg/1 or where elevated levels of chlorides are present, softening may produce a salty taste in the water. In these instances, a by-pass line can be installed from before the softener to a kitchen faucet; or a point-of-use treatment device can be used (see below).

If excessive iron and manganese are present, it may be necessary to remove these metals prior to softening. While water softeners will remove small amounts of iron and manganese, excessive amounts will foul the water softener. As a rule of thumb, the total amount of iron and manganese should not exceed 1.0 mg/l for every 140 mg 1 (8 gpg) of hardness.

1. **Point-of-Use Devices:** Where the taste of the water or the increased amount of sodium due to softening is a concern, a point-of-use device may be used to produce a limited amount of water per day for drinking and cooking. These devices are small, multi-step treatment system designed to fit under the kitchen sink. They produce up to 15 gallons per day of treated water. The treated water is stored in a small pressure tank, piped to a special faucet on the sink. Each of the treatment steps is in a cartridge form and requires periodic replacement.

2. **Laundry Water Softening:** Water for laundry may be softened in the washing machine by using a group of chemicals known as non-precipitating water softeners. This group includes borax, washing soda, trisodium phosphate, and ammonia. Always follow the manufacturer's instructions in using these chemicals. Under no circumstances should these chemicals be used for softening drinking water.

Hydrogen Sulfide

Hydrogen sulfide is a flammable gas produced by the decay of organic material. Because it vaporizes almost instantly, hydrogen sulfide is very difficult to detect analytically in a water sample. Generally, the odor of hydrogen sulfide is enough to determine its presence. Although an official limit has not been established for hydrogen sulfide in drinking water, a recommended limit of 0.05 milligrams per liter (mg/1) has been proposed.

CAUSES:

Hydrogen sulfide is a dissolved gas that occurs naturally in water supplies as a result of the decomposition of underground deposits of organic material.

Hydrogen sulfide can also appear suddenly in wells as a result of the growth of a group of bacteria known as “sulfate reducing” bacteria. These bacteria break down the naturally occurring sulfate compounds in the water, producing hydrogen sulfide as a by-product. Disinfection of the well system is generally sufficient to remove the sulfate reducing bacteria.

In some cases, hydrogen sulfide will occur only in the hot water as a result of a chemical reaction in the water heater itself. Most water heaters contain a corrosion protection device known as a “sacrificial anode.” When dissolved sulfate compounds come in contact with the anode, the resulting chemical reaction converts the sulfates into hydrogen sulfide.

Removal of the sacrificial anode will generally eliminate the problem. However, this may void the warranty on the water heater. The manufacturer’s service representative can best advise you in this regard.

EFFECTS:

The most noticeable effect of hydrogen sulfide is the “rotten egg” odor and sulfur taste it gives to water. The odor and taste of hydrogen sulfide can be detected at levels as low as two-hundreths of a milligram per liter. At the levels normally occurring in drinking water, hydrogen sulfide is not considered a health hazard.

The presence of hydrogen sulfide speeds up the corrosion of metal plumbing materials. It will attack iron, steel, copper, and galvanized plumbing, producing a black color in the water. The effects of corrosion by hydrogen sulfide may go unnoticed for as long as several months, then suddenly become severe.

In combination with dissolved iron, hydrogen sulfide can produce black stains in plumbing fixtures and laundry. A black deposit may also collect in piping and on fixtures.

TREATMENT:

Activated carbon filters, sometimes sold as "taste and odor" filters, are not effective for hydrogen sulfide removal. Some form of chemical oxidation is the most effective method of removal. In chemical oxidation, the hydrogen sulfide is converted to an insoluble sulfur particle, which is then collected on a filter. Some of the sulfide may be converted to a sulfate compound which remains dissolved in the water. The following methods are generally acceptable for sulfide removal:

1. **Automatic Chlorination and Filtration:** With this method, small amounts of a chlorine solution are continuously added to the water using a small metering pump. The chlorine chemically oxidizes the hydrogen sulfide to an insoluble sulfur particle which can then be filtered. The filter must be periodically backwashed to remove the accumulated sulfur.

2. **Manganese Zeolite (Greensand) Filters:** Greensand filters use a filter material that contains manganese dioxide. This compound releases an atom of oxygen to oxidize the hydrogen sulfide. The oxidized particles are then collected on the filter bed. These filters require periodic regeneration with potassium permanganate to replace the oxygen used in the removal process. Backwashing is also required to remove the accumulated sulfur.

3. **Water Softeners:** Water softeners may be used for hydrogen sulfide removal only under certain conditions. Always check the manufacturer's recommendations before using softeners for sulfide removal.

Iron and Manganese

Iron and manganese are naturally occurring metallic elements that closely resemble each other in the way they react in water. Small amounts of iron and manganese will seriously affect the usefulness of the water for household purposes. The recommended limits in drinking water are 0.3 milligrams per liter (mg/1) iron, 0.05 mg/l manganese, or a total of no more than 0.3 mg/l for both.

CAUSES:

The presence of iron and manganese is common in well water. The metals are dissolved from soils and rocks as the water passes through the earth. It is not unusual to find iron concentrations as high as 5 mg/l in some areas. Manganese occurs naturally in lesser amounts than iron. Therefore, it will be found in well water less frequently and in smaller concentrations than iron.

The corrosion of galvanized or steel plumbing materials will dissolve iron into the water. With galvanized metal, zinc will also be dissolved.

EFFECTS:

Iron and manganese are essential and beneficial elements. There is no evidence to indicate that the amount of iron and manganese normally found in well water is harmful. In fact, a normal diet provides an average of 16 milligrams (mg) iron and 10 mg manganese per day.

When dissolved in water, iron and manganese are colorless. However, if allowed to stand, the iron will combine with the oxygen in the air, first turning the water cloudy, then orange, and then forming a reddish deposit on the bottom of the container. This process is called oxidation. Iron may also form an oily film on top of the water.

Manganese reacts similarly, but produces a gray or black deposit. Manganese will cause a coating to form inside the plumbing. This coating will periodically break free, causing black particles to appear in the water.

Iron and manganese will give water a bitter, metallic taste. Coffee and tea prepared with the water may turn black. Deposits from these metals will cause stains on plumbing fixtures, appliances, and in laundry. Bleaches or scouring powders will not remove the stains and may make them worse. Special products designed to remove rust stains are available in most grocery stores.

Deposits of iron and manganese can accumulate in pressure tanks and water heaters. If appreciable amounts of these metals are present, pressure tanks and water heaters should be drained regularly to remove the deposits.

For most iron removal processes, any acidity in the water must first be neutralized. As a general rule, the pH should be at least 6.5, with a minimum alkalinity of 100 mg/l.

1. **Automatic Chlorination and Filtration:** Using a metering pump, small amounts of a chlorine solution are continuously added to the water. The chlorine chemically oxidizes the iron, producing an insoluble rust particle which can then be filtered out with a sand or activated carbon filter. The filter must be periodically backwashed to remove the accumulated iron.

   Activated carbon filters will also remove any excess chlorine not used in the iron removal. However, the carbon must be periodically replaced.

2. **Manganese, Zeolite (Greensand)Filters:** This method uses a material which contains manganese dioxide. This compound releases an atom of oxygen to oxidize the dissolved iron and manganese. The oxidized particles are then collected on the filter bed. These filters require periodic regeneration with potassium permanganate to replace the oxygen used in the removal process. Backwashing is also required to remove the accumulated iron.

3. **Birm Filters:** Birm is a material containing large amounts of manganese dioxide. Using the dissolved oxygen in the water, manganese dioxide accelerates the oxidation of iron and manganese. With sufficient dissolved oxygen present, only periodic backwashing is required to clean the accumulated iron from the filter. Birm filters cannot be used with water containing hydrogen sulfide.

4. **Water Softeners:** Water softeners remove iron and manganese by replacing them with sodium from the filter bed. Softeners are periodically regenerated with a salt solution to replace the sodium used in iron removal. Extremely high concentrations of iron and manganese may foul the filter bed, preventing regeneration. Always check the manufacturer's recommendations before using softeners for iron removal.

5. **Polyphosphates:** Polyphosphates do not remove iron and manganese. They reduce staining by holding the metals in solution, preventing oxidation. Heating the water will cause the polyphosphates to break down, releasing the metals back into the water. Polyphosphates are only effective on amounts of iron

and manganese less than 1 mg/l. The pH should be between 6.8 and 7.4 for optimum performance.

6. **Iron Due to Corrosion:** This type of iron may be eliminated by chemically neutralizing the acidity of the water. Please refer to the Section entitled “Corrosive Water” for further information.

IRON BACTERIA

Water containing iron and manganese in substantial amounts can cause the growth of iron bacteria. Iron bacteria is not a known health problem, but more of a nuisance. When dissolved iron and oxygen are both present in the water, these bacteria derive the energy they need for their life processes from the oxidation of the iron to its insoluble form. These bacteria accumulate within a slime-like substance which covers submerged surfaces. A slimy, rust-colored film on the interior surface of flush tanks of comodes is a fairly good indicator of the presence of iron bacteria.

Iron bacteria can reduce the output of the well by clogging the pump and/or the piping. A gradual decrease in water pressure is a good indicator of this. This bacteria may also cause an unpleasant taste and odor (similar to rotten eggs) to the water or discolor and spot fabrics and plumbing fixtures. A detectable slime also builds up on any surface with which the water containing these organisms comes in contact. Iron bacteria may be concentrated in a specific location and may periodically break loose and appear as bits of rust colored material.

Iron-removal filters or water softeners may remove iron bacteria; however, they often become clogged and fouled very soon because of the slime buildup. A disinfecting solution, such as chlorine bleach, should be poured into the well to control the growth of iron bacteria. The chlorine causes a chemical reaction which makes the iron precipitate out. This deposit can then be removed with a suitable fine filter.

INSTRUCTIONS FOR DISINFECTING A WELL SYSTEM

1. To disinfect the well, one gallon of household bleach is usually sufficient. Pour the bleach directly into the well and allow to sit for a couple hours. If possible, try to get some along the inner casing of the well.

2. Next, open all cold water faucets inside the house until the odor of chlorine can be detected at the faucet.

When the chlorine odor becomes noticeable, turn off all faucets and allow the system to remain idle for 12 to 24 hours. By doing so, you have gotten the chlorine solution in all of the piping. DO NOT USE THE WELL AT ALL DURING THIS PERIOD.

3. At the end of the disinfection period, open either the pressure tank faucet or an outside faucet and allow the water to run until the chlorine odor can no longer be detected, usually an hour is a sufficient time. Using an outside faucet prevents flooding the septic tank system with chlorinated water.

4. Complete the procedure by opening all other faucets until the chlorine can no longer be detected, to remove the last bit of chlorine in the system.

5. Repeat steps 1-4 once a week for three weeks. Further disinfection may be performed as the need arises.

Lead

Lead in drinking water is toxic, even at very low levels. The U. S. Environmental Protection Agency eliminated the maximum contaminant level for lead in 1992, replacing it with an action level of 0.015 milligrams per liter (mg/l) as measured at the consumers tap. Because of the health effects associated with lead, even at very low levels, any amount of lead in drinking water is undesirable.

CAUSE:

It is rare for lead to be found naturally in drinking water. The primary cause of lead in drinking water is the corrosion of home plumbing materials containing lead. This includes lead solder and flux used to join copper pipes, lead pipes and service connections, and lead alloy pipes.

A soft, acidic water will more readily dissolve lead. The concentration of lead in water will increase with the length of time the water stands in the pipes.

Houses less than five years old with lead in the plumbing materials are more likely to have elevated lead in the drinking water. With time, most plumbing will develop a protective mineral coating inside the pipes which insulates them from the corrosive action of the water. During the first five years, the plumbing has not had time to develop this protective coating and is more subject to corrosion by the water.

EFFECTS:

Lead is toxic to the human body. It can cause damage to the brain, nervous system, kidneys, and red blood cells. Pregnant women, fetuses, infants, and young children are at the greatest risk of lead poisoning, even if exposed to lead for only a short time. Infants, who consume most of their food in liquid form (baby formula), can receive very large doses of lead through drinking water.

Growing children absorb lead more rapidly than adults. Low levels of lead can have much larger impact on their small bodies than on an adult. Overexposure to lead during this stage of life can permanently stunt their growth.

TREATMENT:

1. **Immediate Steps:** Do not drink or cook with water that has been in contact with the plumbing for longer than six hours (such as overnight or during a work day). Before using, flush the faucet by letting it run until the water feels cooler. Normally, two to three minutes of flushing will be sufficient to remove the metal-containing water from the pipes.

Never use hot water from the tap to cook with. Hot water is more corrosive than cold water and may contain higher levels of lead. *Especially do not use hot water from the tap for making infant formula.*

2. **Corrosive Water:** Acidic water can be treated to make it less corrosive. Please refer to the Section entitled "Corrosive (Acidic) Water" for further information.

3. **Point-of-Use Devices:** In some cases, it will only be necessary to treat the small amount of water actually used for drinking and cooking. Here, point-of-use devices are a reasonable alternative. Point-of-use devices are small treatment units which produce up to 15 gallons of water per day for drinking and cooking. The device is usually located near the kitchen sink. All of the methods described below are available as point-of-use devices.

4. **Reverse Osmosis (RO):** RO units remove dissolved minerals (including lead) by forcing the water, under pressure, through a synthetic membrane. The membrane contains microscopic pores that will allow only molecules of a certain size to pass through. Since the molecules of dissolved minerals are large in comparison to water molecules, the water will squeeze through the membrane leaving the minerals behind. A properly operated RO unit is capable of removing 90 to 99 percent of the dissolved lead from a water supply.

5. **Distillation:** Distillation units are better known as "stills." They are made of either heat resistant glass or stainless steel. Stills work by heating small amounts (less than 2 gallons) of water to produce steam. The steam is then collected and condensed back into water. The dissolved lead will not vaporize and is left behind in the heating chamber.

Stills require frequent, rigorous cleaning to remove the baked-on mineral salts. The "flat" taste from boiling the water can be reduced by pouring the water back and forth between two containers to aerate it.

6. **Bottled Water:** Where treatment is not desirable or practical, bottled water may be used as an alternative source of drinking water. A chemical analysis of the water (including the lead concentration) will sometimes be listed on the label.

Nitrate/Nitrite

Nitrate and nitrite are naturally occurring inorganic chemicals that make up part of the nitrogen cycle. The nitrogen cycle is the movement of nitrogen, in different chemical forms, from the environment to organisms and then back to the environment. As part of the nitrogen cycle, bacteria convert nitrogen gas from the atmosphere into nitrate and nitrite and then back again as the cycle continues. Nitrate is the more stable of the two chemicals and is therefore more abundant in soils.

CAUSES:

Common sources of nitrate include application of fertilizers, use of septic systems, concentration of animal waste, and decomposition of plant residues. Since nitrate and nitrite occur naturally in the environment, small amounts might be present in water. Nevertheless, human activities can significantly influence these levels. Municipal and industrial wastewater and animal feed lots are major point sources for nitrate and nitrite in water. Concentrated use of septic tanks along with runoff or leachate from the use of fertilizer are some of the main nonpoint sources. Once in the soil, nitrate/nitrite is very mobile. It is water soluble and moves easily through the soil at virtually the same speed as water.

Food, rather than water, accounts for the major human intake of nitrate and nitrite. Both are found in many foods, especially leafy vegetables such as spinach and lettuce. The next largest source of dietary nitrate and nitrite comes from cured meats.

EFFECTS:

The Environmental Protection Agency (EPA) and State of South Carolina have set a maximum contaminant level (MCL) of 10.0 mg/L. High levels of nitrate in drinking water are a health concern primarily because of the potential for the nitrate to be converted to nitrite. Nitrite interferes with the ability of your blood to carry oxygen. It does this by converting blood hemoglobin into methemoglobin. Unlike hemoglobin, methemoglobin does not function as an oxygen carrier to the tissue. The resulting condition is known as methemoglobinemia and causes severe oxygen deficiency and can lead to death. The sensitive populations are infants, individuals with reduced gastric acidity, individuals with a hereditary lack of methemoglobin reductase, and women who are pregnant. Methemoglobinemia is usually found in infants rather than adults, especially infants less than six months of age. It is characterized by shortness of breath and blueness of skin. As a result, it is often called the "blue baby syndrome." Healthy adults can consume large quantities of nitrate in drinking water with relatively little, if any, adverse effects. Please contact a physician for more information on the effects.

TREATMENT:

There is no simple way to remove nitrate from water in the home. Nitrate does not evaporate the way chlorine does. Boiling, freezing, or letting water stand does not reduce the nitrate level. Home water treatment units are generally a limited option. A properly operating distillation system will remove nitrate. Reverse osmosis and anion exchange units are other options. These methods are both discussed in other sections of this book.

Sodium

For normal, healthy persons, the amount of sodium in drinking water is a minor contribution to their total dietary intake of sodium. However, for those people who must restrict their salt intake to control certain medical conditions, sodium in drinking water can be a major concern. The U.S. Environmental Protection Agency has proposed a recommended concentration of 20 milligrams per liter (mg/1).

CAUSES:

Every natural water supply contains some sodium. The amount depends on its contact with soluble sodium compounds in the earth and air. In coastal areas, salt spray and the intrusion of salt water into underground fresh water supplies can also affect the sodium concentration.

Human sewage and household washing products contain high concentrations of sodium. If a sudden salty taste is noticed in a well water normally low in sodium, it may indicate sewage contamination.

Some chemicals and processes used to treat water will increase the sodium content. This is especially true of soda ash (sodium carbonate), used in neutralizing acidic water, and water softeners. Water softeners work by exchanging sodium for the calcium and magnesium that cause hardness. For every mg/l of hardness removed, a softener will increase the sodium concentration 0.5 mg/1.

EFFECTS:

Excessive sodium in drinking water can produce an increase in blood pressure as a person ages. This can eventually lead to the development of hypertension in people with a family history of the disease.

Sodium restricted diets are used to control disease conditions in approximately 3 percent of the population. A sodium concentration in drinking water of 20 mg/l is considered to be compatible with a 500 mg sodium per day diet. The average person, consuming two liters of water per day containing 20 mg /l sodium, would add 40 mg of sodium to their daily intake. By comparison, one cup of whole milk adds 122 mg of sodium; one slice of white bread, 114 mg; and a large fast food hamburger, about 990 mg.

Sodium levels above 250 mg/l will affect the taste of the water. If high amounts of both sodium and chlorides are present, the water may taste salty; elevated sulfates and sodium will produce a bitter taste.

TREATMENT:

Sodium compounds dissolve very easily in water. Once dissolved, they are very difficult and expensive to remove. Because sodium has little effect on other domestic uses, it is usually necessary to treat only the water used for drinking and cooking.

The methods described below are available as point of-use devices. These are small treatment units which produce up to 15 gallons of water per day for drinking and cooking. The device is usually located near the kitchen sink. Where treatment is not desirable or practical, bottled water that is sodium-free or distilled may be used as an alternative.

1. **Reverse Osmosis (RO):** RO units remove dissolved minerals by forcing the water, under pressure, through a synthetic membrane. The membrane contains microscopic pores which will allow only molecules of a certain size to pass through. Since the molecules of dissolved minerals are large in comparison to water molecules, the water will squeeze through the membrane leaving the minerals behind. A properly operated RO unit is capable of removing about 80 percent of the dissolved sodium from a water supply.

2. **Distillation:** Distillation units are better known as "stills." They are made of either heat-resistant glass or stainless steel. Stills work by heating small amounts (less than 2 gallons) of water to produce steam. The steam is then collected and condensed back into water. The dissolved sodium and other minerals will not vaporize and are left behind in the heating chamber.

   Stills require frequent, rigorous cleaning to remove the baked-on mineral salts. The "flat" taste from boiling the water can be reduced by pouring the water back and forth between two containers to aerate it.

3. **Deionization (DI):** Deionization units are available as small, wall-mounted cartridges containing ion exchange resins. When water passes through the cartridge, the dissolved sodium and other mineral salts are retained in the resin, producing a mineral-free water. The DI cartridges usually show a color change in the resin to indicate when they should be replaced.

4. **Combination Point-of-Use Devices:** These are multistep systems which use a pre-filter, RO membrane or DI cartridge, and a carbon polishing filter. They treat up to 15 gallons of water per day. The treated water is stored in a small pressure tank and piped to a special faucet on the kitchen sink.

Total Dissolved Solids

Total Dissolved Solids (TDS) refers to the dissolved mineral content of the water. The recommended limit for TDS is 500 milligrams per liter (mg/1). This is the concentration where most people will notice a bitter, salty, or medicinal taste in the water. While elevated levels of TDS are not a health hazard, there is also no proof that drinking a highly mineralized water is beneficial to health.

CAUSE:

The TDS concentration in a water is the result of the amounts and types of minerals dissolved into the water from the surrounding earth and rocks. Generally, well water near coastal regions will have an elevated TDS level. This is a result of both the nearness of the ocean and deposits left by the ocean in prehistoric times. "Hard" water will also have a correspondingly high level of TDS.

EFFECTS:

The most noticeable effect of excessive TDS is the taste it gives to water. If a large part of the TDS are chlorides, the water will have a salty taste. Sulfates will produce a bitter taste; while bicarbonates give the water a medicinal taste. When sulfates make up most of the TDS, visitors to the area will notice a temporary laxative effect after drinking the water. The sulfates occurring in TDS are commonly known as Glauber's Salt and Epsom Salt.

Household plumbing and appliances will deteriorate faster in a mineralized water. Elevated levels of dissolved solids and chlorides increase the ability of the water to conduct an electrical current. The increase in conductivity accelerates corrosion by making it easier for the chemical reactions involved in corrosion to occur.

Total dissolved solids can also be responsible for scaling in water heaters, spotting on dishes, particles forming in ice, rings on cooking utensils, and particles forming in food during cooking.

TREATMENT:

With TDS, the treatment process must deal with a number of different mineral compounds or "salts." The available treatment processes for TDS while effective, are relatively more expensive than treatment for other water quality problems, such as iron removal.

Of the available treatment processes for TDS, reverse osmosis (RO) and deionization (DI) units are the only ones capable of treating the entire household supply. Because deionized water is also corrosive, DI units are not recommended for whole-house use.

Where only the taste of the water is of concern, point of-use devices are another means for treating TDS. These are small treatment units which use distillation, deionization, reverse osmosis, or ultra filtration to treat only enough water for use in drinking and cooking. They are limited to a production of from 10 to 15 gallons of water per day.

1. **Reverse Osmosis (RO):** RO units remove TDS by forcing the water, under pressure, through a synthetic membrane. The membrane contains microscopic pores which will allow only molecules of a certain size to pass through. Since the molecules of dissolved mineral salts are large compared to the water molecules, the water will squeeze through the membrane leaving the mineral salts behind.

   A properly operated RO unit is capable of removing 90 percent of the dissolved mineral salts from a water supply. A pre-filter is usually required to protect the membrane from abrasion. The membrane cartridges require periodic replacement.

2. **Distillation:** Distillation units are better known as "stills." They are manufactured from heat-resistant glass or stainless steel. Stills work by heating small amounts (less than 2 gallons) of water to produce steam. The steam is then collected and condensed back into water. The dissolved mineral salts will not vaporize and are left behind in the heating chamber.

   Stills require frequent, rigorous cleaning to remove the baked-on mineral salts. The "flat" taste from boiling the water can be reduced by pouring the water back and forth between two containers to aerate it.

3. **Deionization (DI):** Deionization units are available as small, wall-mounted cartridges containing ion exchange resins. When water passes through the cartridge, the dissolved minerals salts are retained in the resin, producing a mineral-free water.

   The DI cartridges have a limited life. They will usually show a color change in the resin to indicate when they should be replaced.

4. **Combination Point-of-Use Devices:** These are multistep treatment systems designed to fit under the kitchen sink. They use a pre-filter, RO membrane or DI cartridge, and a carbon polishing filter top produce up to 15 gallons of water per day. The treated water is stored in a small pressure tank and piped to a special faucet on the sink. Each of the treatment steps is in a cartridge form.

Zinc

Zinc is a naturally occurring metallic element. Although it is commonly found in rocks and minerals, zinc is seldom found naturally in well waters in more than trace amounts. The recommended limit for zinc in drinking water is 5 milligrams per liter (mg/1).

CAUSE:

The principal cause of zinc in drinking water is the corrosion of galvanized metal. When galvanized metal is exposed to an acidic water, zinc is dissolved from the exposed surface, along with iron and trace amounts of lead and cadmium. The concentration of zinc in the water will be highest after the water has been in contact with the metal for long periods of time.

Water having high concentrations of total dissolved solids or chlorides will also dissolve zinc from galvanized metal. Elevated levels of dissolved solids and chlorides increases the electrical conductivity of the water, making it easier for the chemical reactions involved in corrosion to occur.

EFFECTS:

Zinc is an essential and beneficial element in human metabolism. The average diet will provide an adult with 10 to 15 milligrams (mg) of zinc per day.

At the levels normally found in drinking water, zinc is not a health hazard. At extremely high concentrations (675 mg/l and above), zinc can act as an intestinal irritant, causing nausea and vomiting. However, there is a wide safety margin between these levels and the amount found in drinking water. Dissolved zinc can cause the water to have a bitter, medicinal taste. Concentrations of 30 mg/L may give the water a milky appearance. When the water is heated, elevated levels of zinc may produce a greasy film on top of the water.

TREATMENT:

Acidic Water: Zinc present as the result of an acidic water may be eliminated by neutralizing the acidity of the water. This may be done by using a metering pump to add small amounts of an alkaline solution (such as soda ash and water) to the water, or by using a neutralizing filter. For further information, please refer to the Section entitled “Corrosive (Acidic) Water.”

Dissolved Solids: Corrosion due to a high concentration of dissolved solids or chlorides may be treated by using a reverse osmosis filter to drastically reduce the solids content. However, this method of treatment is very expensive.

An alternative treatment would be to use a polyphosphate compound. Polyphosphates are known as corrosion inhibitors. They will not reduce the dissolved solids content of the water, but will help to protect the plumbing from corrosion by forming a protective coating on the exposed metal surfaces. For additional information, please refer to the Section entitled “Total Dissolved Solids.”

Region EQC Offices

Region 1
Anderson and Oconee Counties
2404 N. Main St., Anderson, SC 29621
Telephone: (864) 260-5569

Abbeville, Edgefield, Greenwood, Laurens
McCormick, and Saluda Counties
613 S. Main St., Greenwood, SC 29646
Telephone: (864) 223-0333

Region 2
Greenville and Pickens Counties
301 University Ridge, Suite 5800, Greenville, SC 29601
Telephone: (864) 241-1090

Cherokee, Spartanburg, and Union Counties
975 N. Church St., Spartanburg, SC 29303
Telephone: (864) 596-3800

Region 3
Chester, Lancaster, and York Counties
2475 DHEC Rd, Lancaster , SC 29720
Telephone: (803) 285-7461

Fairfield, Lexington, Newberry, and Richland Counties
Bldg. 5 (P.O. Box 156), State Park, SC 29147
Telephone: (803) 896-0620

Region 4
Chesterfield, Darlington, Dillon, Florence, Marion, and
Marlboro Counties
145 E. Cheves Street, Florence, SC 29506
Telephone: (843) 661-4825

Clarendon, Kershaw, Lee, and Sumter Counties
105 Magnolia St., P.O. Box 1628, Sumter, SC 29151
Telephone: (803) 778-6548

Region 5
Aiken, Allendale, Bamberg, Barnwell, Calhoun, and Orangeburg Counties
206 Beaufort St., N.E., Aiken, SC 29801
Telephone: (803) 641-7670

Region 6
Georgetown, Horry, and Williamsburg Counties
927 Shine Avenue, Myrtle Beach, SC 29577
Telephone: (843) 238-4378

Region 7
Berkeley, Charleston, and Dorchester Counties
1362 McMillan Ave., Suite 300, Charleston, SC 29405
Telephone: (843) 953-0150

Region 8
Beaufort, Colleton, Hampton, and Jasper Counties
104 Parker Drive, Beaufort, SC 29906
Telephone: (843) 846-1030

Printed September 2007

Total printing cost: $675
Total number printed: 500
Cost per unit: $1.35

Notes

http://www.scdhec.gov/environment/water/

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and Environmental Control

CR-006453 3/08